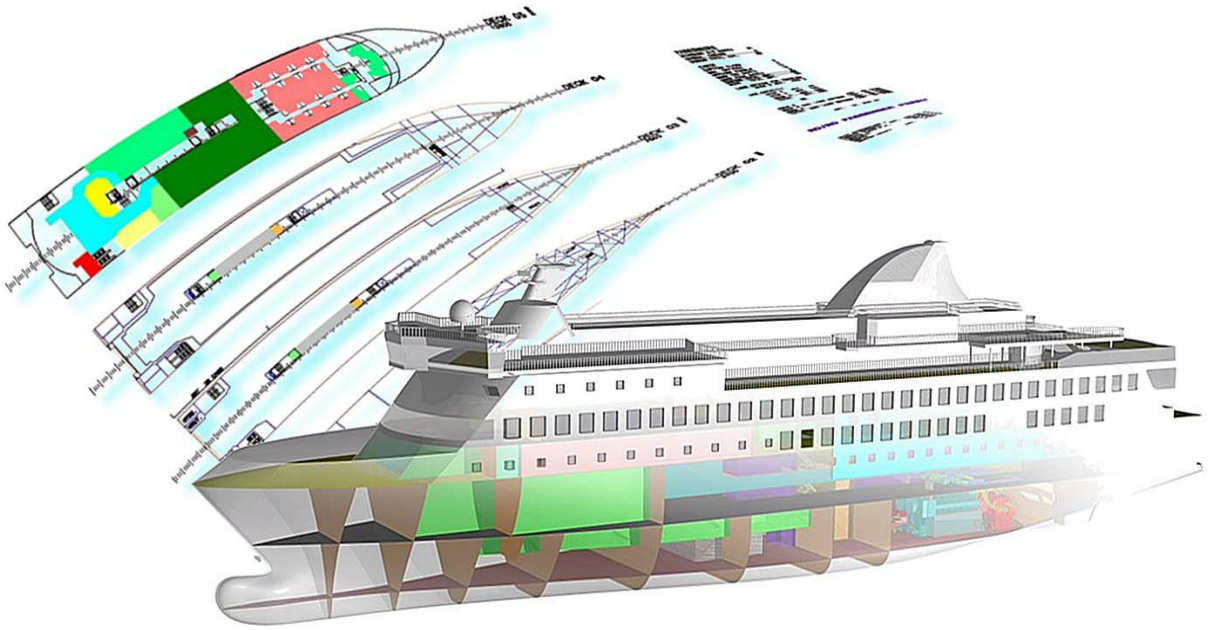
IBM PLM Version 5 Solutions for Shipbuilding

Setting the course and strategy for digital shipbuilding

PLM Solution Offerings: End-to-End Concept to Float-out



An IBM / Dassault Systèmes Thought Leadership Paper

December 5, 2003

Preface

As the leading providers of information technology solutions for the global shipbuilding industry, IBM and Dassault Systèmes have worked with many major yards, design companies and consultants to understand the shipbuilding process from concept to float-out and to identify common challenges and devise innovative, end-to-end solutions. Highlights of that effort are presented in a new Thought Leadership Series of papers called *Setting the Course and Strategy for Digital Shipbuilding*. These papers are jointly authored by IBM and Dassault Systèmes. Each paper examines a different aspect of the challenges currently facing shipyards and the ways in which Product Lifecycle Management from IBM (PLM) has been designed to resolve them.

This paper, "PLM Solution Offerings: End-to-End Concept to Float-Out," is one in the series. It focuses on applications for Engineering and Manufacturing Authoring, Lifecycle Management and Decision Support. Other topics in the series will include overviews of shipbuilding economics; digital manufacturing; best practices; and PDM, digital mockup and collaboration. Some papers in the series will be confidential and subject to non-disclosure agreements with customers. This paper is not confidential.

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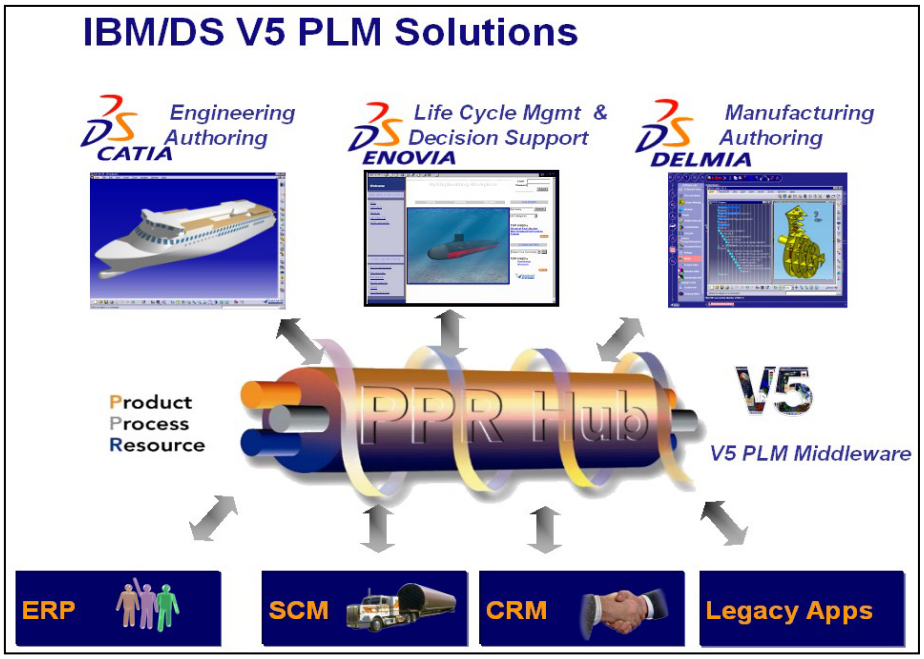
Introduction

Since 2001, IBM, worldwide provider of PLM Solutions marketing, sales and service support, and Dassault Systèmes, its strategic research and development partner for 3D CAD/CAM/CAD and PDM solutions, have announced a suite of next-generation solutions for the shipbuilding industry. The two companies' commitment to research, development and applications in new shipbuilding are unprecedented in the shipbuilding industry. In the rest of this paper, the PLM Solutions developed by Dassault Systèmes and marketed and supported by IBM will be called IBM PLM Solutions. They offer the latest features in conceptual design, outfitting and digital manufacturing. Today, IBM PLM Solutions is the most comprehensive CAD/CAM/CAE and PDM solution set in the world of shipbuilding.

IBM has introduced these new releases to meet the demand from yards that are focusing more than ever on design-for-production in an e-business framework. Shipbuilders are focusing more attention on early conceptual design and simulation where design intent, system performance and the revenue-producing considerations of a ship are defined and optimized. The business realities of shipbuilding require integrated MCAD and PDM along with shipbuilding-specific functions and effective teamwork.

"Shipbuilders are turning to IBM solutions because of increasing international competition and the necessity to build more value-added, sophisticated ships," said John MacKrell, shipbuilding analyst at CIMdata. "To accomplish this, shipbuilders are, in large numbers, migrating to a 3D product model design environment and thus are eager to implement offerings such as the blend of technology and best practices provided by IBM and Dassault Systèmes. These two companies, working in a long-established partnership, have stepped forward to make a real commitment to the shipbuilding industry."



This paper provides an overview of the entire IBM Product Lifecycle Management (PLM) offering for shipbuilding. The offerings presented here are grouped into four categories:

Engineering and Manufacturing Authoring Tools - a set of products allowing engineering and manufacturing technical end-users to create discipline-specific digital data and to define and simulate production.

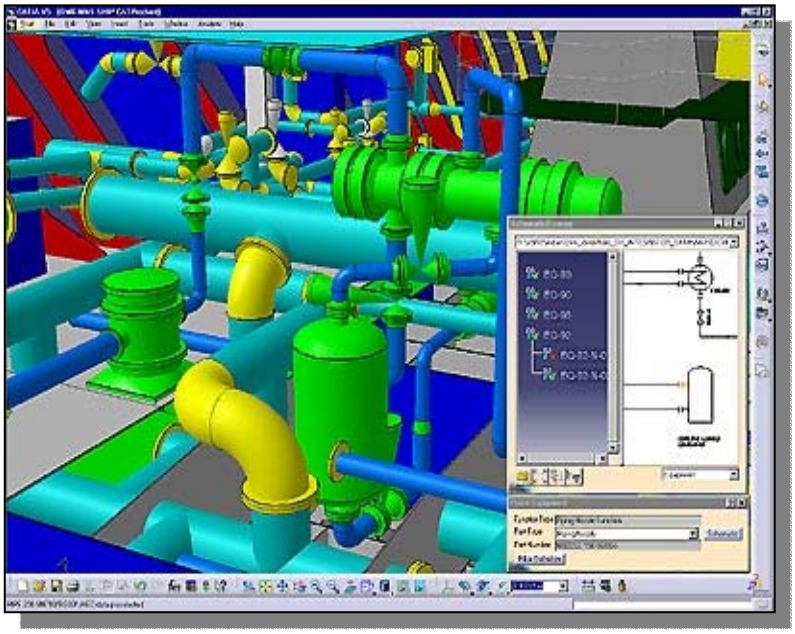
Lifecycle Management Solutions - a set of products for storing, retrieving and managing the ship digital data and addressing shipyard collaboration needs.

Decision Support - a set of products that allows executives and managers to access and visualize up-to-date shipyard digital information through an internet portal.

V5 PLM Middleware - a set of software products that allows V5 applications to use a common infrastructure and supports shipyard mechanisms in integrating legacy data and applications with IBM PLM Solutions. Descriptions of these offerings are covered in another paper in this Thought Leadership series.

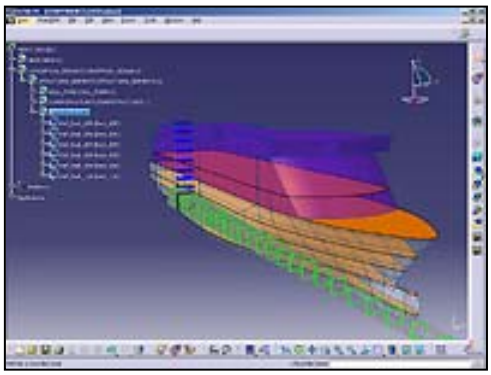
Interfaces between the IBM PLM Solutions and other I/T resources at the shipyard are developed around the Product Process Resource (PPR) data model, which leverages Dassault Systè'mes V5 PLM Middleware and IBM Websphere. These middleware components facilitate the development of interfaces with a shipyard's Enterprise Resource Planning (EPR) systems, Customer Relationship Management (CRM), Supply Chain Management (SCM) and legacy systems.

Engineering Authoring Tools



Conceptual Design

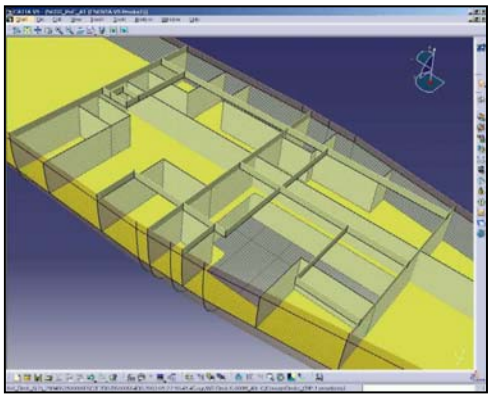
Structures Preliminary Layout (SPL)



CATIA ***Structures Preliminary Layout*** (SPL) provides a set of tools for shipbuilding designers at the preliminary-draft phase who wish to set up the early definition of the major ship divisions. It defines hull shape, identifies main decks and bulkheads and characterizes general arrangements. Hull forms can be imported from naval architecture packages or defined using other CATIA *Advanced Surfacing* or *Generative Shape Design* applications. *Structures Preliminary Layout* creates molded forms inside the hull form, allowing users to create openings and then define compartment volumes that divide the ship's space. It can also be used with other CATIA applications such as *System Routing*, where volumes are reserved for long-run systems including HVAC, piping or cable trays. *Structures Preliminary Layout* was developed to help designers optimize revenue-generating spaces such as cabins, shipboard thematic areas and shops on cruise liners or cargo areas on commercial ships. Other functions assist in creating estimates of weights/balances.

All structure applications integrate seamlessly with applications such as automatic *Generative Drafting.* Yards benefit from broad project lifecycle support starting at early conceptual phase where the focus is on optimizing design activities and pre-planning for production. Suppliers of long-lead equipment and classification societies that validate layout and design rules benefit from collaboration tools linking these structures applications with IBM PLM e-business collaboration tools such as ENOVIA *3dCOM*. Owners/operators and naval architects benefit from simple functions to define and compare preliminary layouts of decks, compartments, large space reservations, etc. Space management optimizes layouts, assists in maximizing revenue-producing areas within the ship and establishes initial general arrangements and space reservations.

Compartment and Access (CNA)



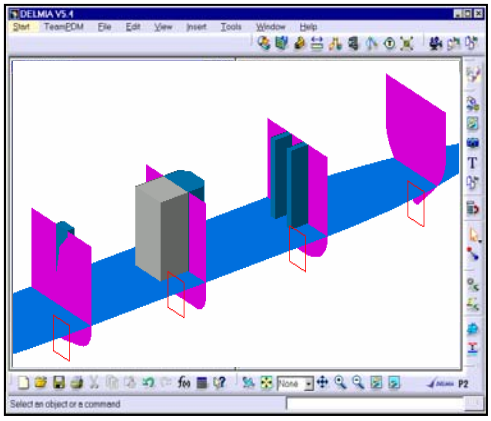
CATIA ***Compartment and Access*** (CNA) is dedicated to the definition of compartment and access objects within a ship design. It is used to define the limits of compartment and access forms (doors, hatches, windows, portholes, etc.) within a ship design. CNA gives the user the ability to define a compartment's boundary surfaces, to place access objects such as doors, windows and stairs into compartments, and to generate unique drawings and reports. A compartment created in CNA can be used to organize downstream system design processes, set the specifications for machinery and support systems passing through the compartment (piping, HVAC, cable trays, etc.), and generate unique bills of material (BOMs). CNA may be used to define wall systems within a deck; define compartments and boundary surfaces within a ship; place access objects such as doors, windows and stairs; define a compartment used to organize downstream system design processes; and provide drawing and report-generation capabilities. CNA is fully integrated with

CATIA – Structure Preliminary Layout, and Functional Design, the entire portfolio of outfitting applications (piping, tubing, HVAC, cable trays, hangers, waveguides, etc.), and with *Generative Drafting.*

Systems Space Reservation (SSR)

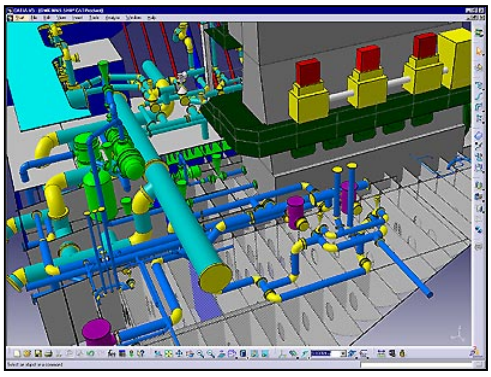
CATIA ***Systems Space Reservation*** (SSR)

SSR is used to reserve or to claim space that is to be filled later in the design process by machinery, circulation spaces (stairs, elevators, halls, and passageways), theaters, atriums etc. Such space must be set aside early in the design process. As the design matures, the contents of the reserved space can be detailed. For example, equipment placed inside or the actual elevator layout can be defined.



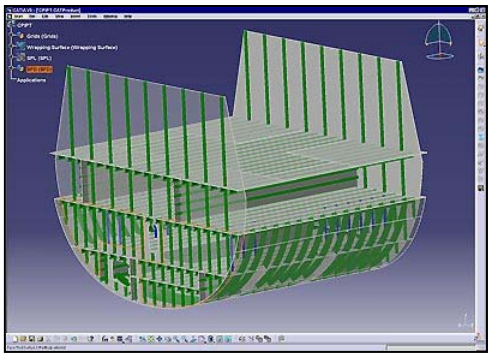
Systems Routing (SRT)

CATIA ***Systems Routing*** (SRT) optimizes the production systems routing for all disciplines, including piping tubing, conveyors, ductwork and raceways. SRT allows users to fully define run definitions and then evolve their designs to actual geometry and parts. This "evolve" capability allows designers to move at their own speed to detail a routing design and allows maximum re-use of previous work. SRT gives users the power and flexibility to manage their system components from initial design to ship operations. From conceptual definition to detailed preliminary routing, SRT allows designers to continually iterate their routing definition.



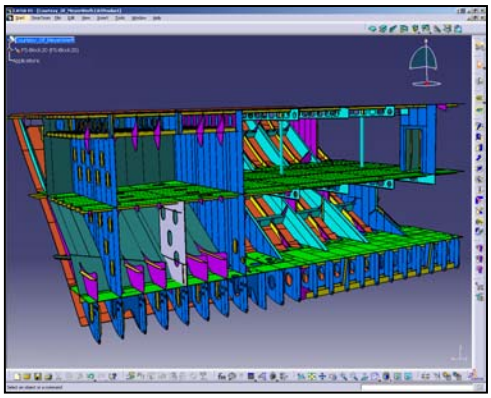
Structural Design

Structure Functional Design (SFD)



CATIA ***Structure Functional Design*** (SFD) enriches *Structure Preliminary Layout* (SPL) by refining and streaking the hull, adding plate thickness on decks and major bulkheads and adding longitudinal and transverse stiffeners. This permits the user to calculate the strength of the structure, to get required approval of the basic design and to extract early weight, material and labor estimates. SFD empowers the user with flexibility for the conception of a structure. This intermediate phase gives a user the chance to modify the design from the conceptual phase, supervising final objectives. SFD offers the following main functions: Object Dictionary and Attributes, Setup Catalogs, Panel Systems, Straking Grid, Functional Plates, Insert Plates, Openings, Functional Stiffeners, Functional Pillars, Functional Standard Parts, Design Progression (associativity between SPL and SFD), BOM (Samples VB Macros) and export of relevant data to AP203 format.

Ship Structure Detail Design (SDD)



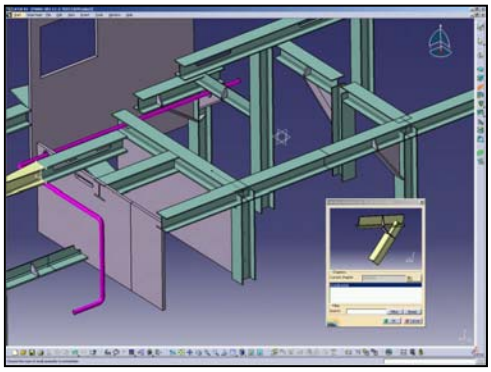
CATIA ***Ship Structure Detail Design*** (SDD) extends structural design capabilities that begin with the conceptual design of the ship (hull form, general arrangement, zone and block definitions). SDD focuses on entire structural systems that often are made of composites or fabricated, assembled and erected from smaller piece parts.

SDD offers highly automatic detailing functions for defining connections, penetrations, cutouts and spanning parts. Small assemblies can be defined using knowledgeware templates and then quickly instantiated thought the ship. Designers are able to assign project resources to various systems for later scheduling, managing work flow, defining work packages and tracking the materials required.

SDD is fully integrated with *Structure Functional Design* (SFD) and is able to retrieve design block information to perform the detailed design of the structure. SDD provides productive tools and an environment that manages structural systems and connections and creates physical plates and shapes. Highlights and benefits include: high-level automation and user productivity; integration of detailing and build plan; an environment that enforces project standards; reusability of small assemblies and piece parts from other build projects; plating/stiffening capabilities; connections; integration with drafting; ability to generate structural parts from design block and existing functional specifications defined with SFD; design block envelope definition and management, a production function; user-dedicated features to manage structural systems and connections; a collection of industry-specific features to use in creating physical plates and shapes; productive tools for incorporating shipyard rules and standards; and

definition of project resources at project level though the integration of Object Dictionary in PRM (Project Resources Management).

Structural Design - Plates and Shapes (SR1)



CATIA ***Structure Design*** (SR1) is a highly productive application that creates straight, curved and twisted structure and planar or surface plates using standard or user-defined sections. All members are fully associative with a user interface optimized for the placement of structures and management of piece parts. Entire assemblies made of sub-parts can be instantiated through user-defined templates. The result is a breakthrough in productivity. The CATIA infrastructure supports parametric catalogs through intelligent design tables. A wide variety of customizable Bills of Material (BOMs) are available. SR1 is fully integrated with CATIA *Analysis* products for downsteam structural analysis.

Users benefit from a single application capable of creating multiple types of linear, curved and twisted structures and assemblies from standard or user-defined sections. A single user interface provides simple-to-use workbench tools. These tools can be used to quickly build structural layouts by referencing existing structures (faces, edges, or vertex) nearby, or hull, deck or compartment features. All structural components maintain full associativity.

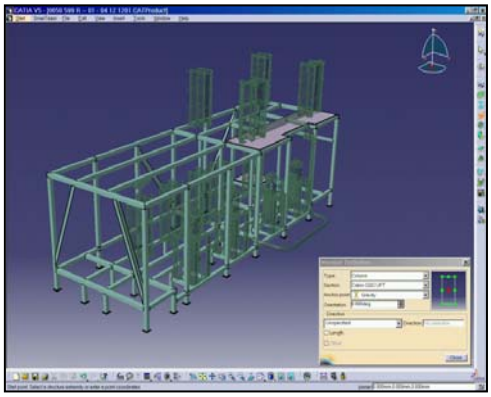
Advanced users will find user-defined structural templates particularly useful when instantiating common structural configurations like braces, collars, stiffeners or reinforced panels or in managing penetrations. Shipbuilders that have focused on streamlining design and production will find assembly templates a useful way to capture best practices on one project and reuse them on another. This method allows users to be extremely productive while ensuring they remain compliant with company standards and best practices. Templates can be used, for instance, to automatically instantiate stiffeners along a beam or to manage for standard penetration of plates (standard opening or cut-out).

Using the standard section catalogs (delivered with the product), the user can define parametric sections or create a custom section catalog easily and intuitively. Users also can create several structures between two reference structures or two edges of plate in a single step. This is accomplished either by specifying the number of "in-fill", the spacing, or by letting the software calculate this number.

Information such as material, section, length to cut and quantity requirements are easy to extract and use for Bills of Material. Visual Basic macros can be written to create customer structure profiles and to automatically generate structure frames. Using CATIA - *Analysis* products, advanced analysis of structural beams can be accomplished. This greatly facilitates the design-to-analysis process, allowing users to directly use what they have just designed to simulate the manufacturability of the structural beams.

Equipment Support Structures (ESS)

CATIA ***Equipment Support Structures*** (ESS) provides tools to simply and quickly create shipboard equipment foundations with linear, curved structures and plates using standard or user-defined sections and cutouts. Taking advantage of an optimized user interface, the user can easily create and modify structures using the ESS capability for full associative design in context. Moreover, the product includes a parametric catalog accessed through design tables. ESS also can generate user-customizable Bills of Material (BOMs). It is natively integrated with other CATIA applications to complete the foundation and equipment mounting designs.



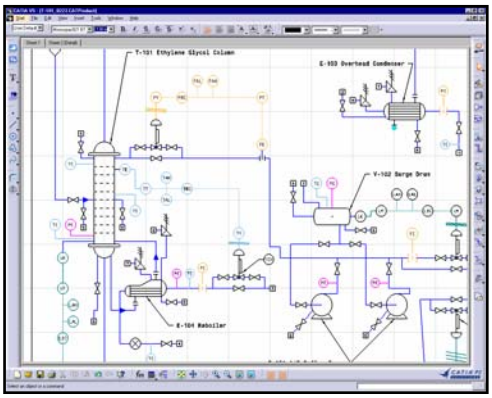
General Systems and Outfitting

Piping Design (PIP)

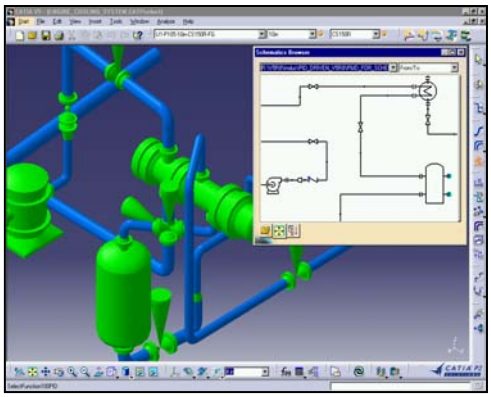
CATIA ***Piping Design*** (PIP) creates and manages logical designs of piping systems using industry standard conventions, terminology and practices. The tools are focused on creating an intelligent piping layout that captures the design intent. With this intelligent piping design product, the user is able to create and validate a design more productively. In addition, captured intelligence can be re-used for downstream design processes, providing additional benefit to the customer's overall design process.

PIP supports the definition of piping configurations. This involves general layout tools for intelligent placement of parts and automatic placement of components such as bends, elbows, tees and reducers. Functionally driven design is used to ensure that design intent is available for any modification scenario. PIP is fully integrated with the design rules engine, allows automation of the design process and ensures that company standards are followed throughout the design process. The 2D Piping and Instrumentation Diagrams product is fully integrated with PIP and provides logical-to-physical integrated design work. This integration also provides high productivity and reduces cycle time.

Piping & Instrumentation Diagrams (PID)

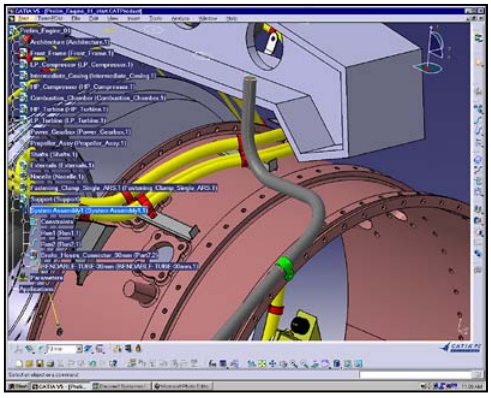


CATIA ***Piping & Instrumentation Diagrams*** (PID) creates and manages logical designs of piping systems using industry standard conventions, terminology and practices. The tools are focused on creating an intelligent diagram that captures all appropriate design information. With this intelligent diagram design, the user is able to create and validate his design in a more productive way. In addition, captured intelligence can be re-used for downstream design processes, providing additional benefit to the customer's overall design process.

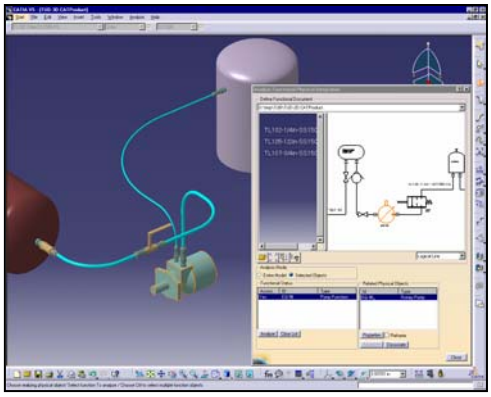


PID supports the definition of piping and instrumentation diagrams. This involves general layout tools to place and locate equipment, as well as the creation and management of piping lines, instrumentation and control loops. In addition, full capabilities allow users to quickly add intelligent annotation to diagrams, query design information and generate appropriate report information. CATIA PID gives users the power to manage their systems, from initial design to ship operations, with complete flexibility.

Tubing Design (TUB) and Tubing Diagrams (TUD)



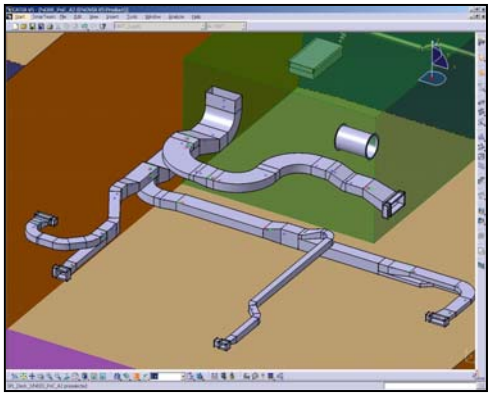
CATIA ***Tubing Design*** (TUB) creates and manages tubing systems using industry standard conventions, terminology and practices. The tools are focused on creating intelligent tubing layouts that capture all appropriate design information such as flow, direction, specification, materials class, connection types etc. The captured intelligence can be re-used for downstream design processes, providing additional benefit to the customer's overall design process. In addition, full capabilities are provided to quickly query design information and generate appropriate report information.



All of these 3D design tools are provided via a highly intuitive and productive user interface that allows the user to quickly create, modify and manage their designs. TUB can be used together with CATIA ***Tubing Diagrams*** (TUD), which provides logical diagramming and 2D schematic visualization of complex systems.

Tubing Diagrams creates and modifies diagrams. Diagram query functions locate particular tubing lines and connected machinery to produce tubing lists, network analysis and other reports. *Tubing Diagrams* is integrated with the *CATIA - 3D Tubing Design* product. When used together, *3D Tubing Design* automatically selects tubing pipe parts, connections and specific tubing based on specifications in the diagram. Thus, *Tubing Diagrams* drives the creation of the 3D tubing design and allows a 2D/3D analysis and reconciliation check. Advanced setup tools are provided, giving users a way to define and associate attributes to tubing lines and parts. *Tubing Diagrams* provides industry standard catalog tools. Starter data includes sample catalogs, sample report formats and sample design checks.

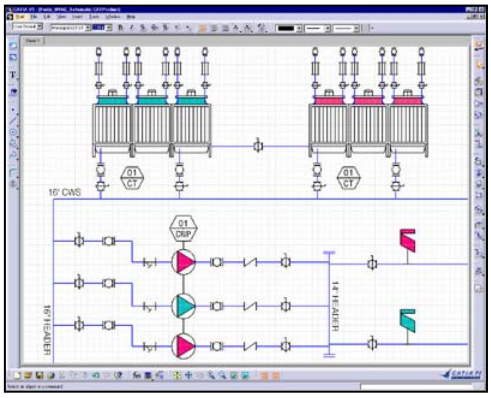
HVAC Design (HVA)



CATIA ***HVAC Design*** (HVA) defines 3D HVAC configurations. This product provides general layout tools for intelligent placement of parts and automatic placement of components as well as the creation and management of duct lines and associated systems. A full set of routing and parts placement methods gives users the choice of how best to place HVAC parts for a given context.

Specification-driven design is used where required to ensure compliance with project standards. Function-driven design is used to ensure that the design intent is available for any modification scenario. Integration with *HVAC Diagram* (HVD), described below, and the design rules engine allows automation of the design process and ensures that company standards are followed throughout the design process. This integration also provides high productivity and reduces cycle time. In addition, full capabilities are provided to quickly query design information and generate appropriate reports and drawings.

HVAC Diagrams (HVD)

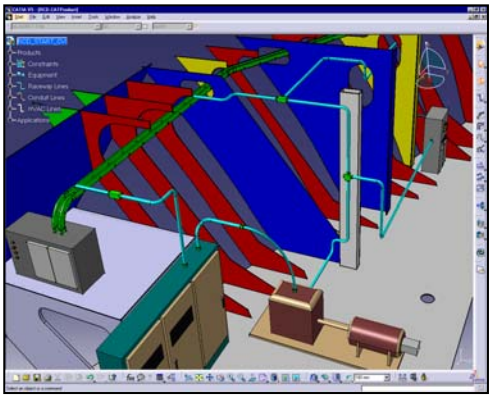


CATIA ***HVAC Diagrams*** *(HVD)* creates and manages logical designs of HVAC systems using industry standard conventions, terminology and practices. The tools create an intelligent diagram that captures all appropriate design information. With this intelligent design, the user is able to create and validate his design in a more productive way. In addition, captured intelligence can be re-used for downstream design processes, providing additional benefit to a user's overall design process.

HVD supports the definition of HVAC diagrams, including general layout tools to place and locate equipment, as well as the creation and management of duct lines. In addition, HVD has full capabilities for annotating diagrams quickly with intelligent annotation, for querying design information and for generating appropriate report information.

Electrical Systems

3D Raceway and Conduit Design (RCD)

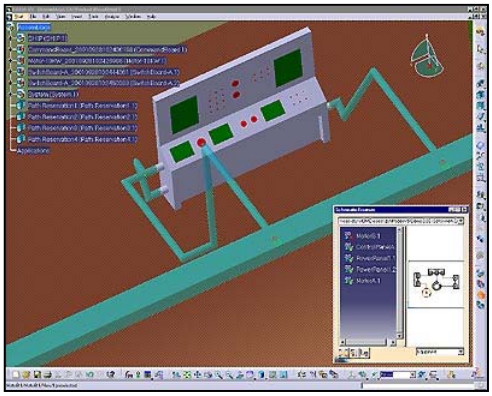


CATIA ***3D Raceway and Conduit Design*** (RCD) provides electrical cable raceway and conduit creation tools. Raceway and conduits are complex 3D routing and support systems running from bow to stern and between decks. This application provides comprehensive 3D layout and routing. Catalog parts obey placement rules, ensuring proper orientation and clearances. Raceway and conduits can be dynamically stretched and modified.

3D Raceway and Conduit Design is integrated with the *3D Cable Routing* application, which uses physical cable networks to manage cable routing definitions. Users benefit from automatic placement of specific cables in a raceway or conduit. *3D Cable Routing* can automatically generate cable lists with the proper cut lengths and bundling information.

3D Raceway and Conduit Design provides query and analysis functions that check designs and integrate the application with knowledgeware. Network connectivity and analysis functions, along with extensive report generation, are provided. Setup tools assist in creating catalog components or in using the industry standard sample raceway parts provided.

Electrical Cableway Routing (ECR)



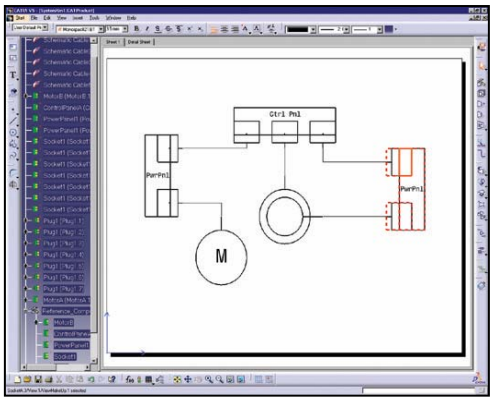
CATIA ***Electrical Cableway Routing*** (ECR) provides cableway routing in 3D. It automatically manages reserved items and placement consistent with electrical connectivity diagrams and the ship's compartment definition.

There is a strong link to the mechanical and structural disciplines as they "carve out" space throughout the ship for major electrical systems. These functions are useful in the early conceptual design phases, when various disciplines define their initial space needs and coordinate their routing plans. *Electrical Cableway Routing* links the various zones on a ship to a series of reservation envelopes that act as a "keep out" area for other services. This feature reduces conflicting uses of space while enforcing yard design standards.

Users also benefit from the associability between 3D shipbuilding structure and 3D cableways. A change in the 3D shipbuilding structure will be reflected in the 3D cableway automatically. Strong integration also exists between electrical schematic and 3D cableway routing. The placement of 3D equipment and the creation of 3D cableways are driven by the schematic data.

Thus, associativity features reduce common sources of errors and enhance collaboration between design teams.

Electrical Connectivity Diagrams (ELD)

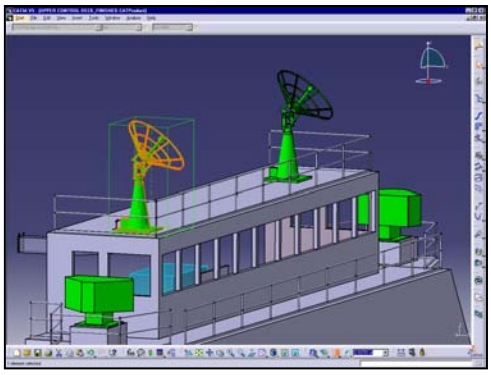


CATIA ***Electrical Connectivity Diagrams*** (ELD) creates and manages logical designs for power distribution and command/control systems used onboard ships. ELD provides electrical catalogs, cable routing and connectivity management tools, full diagramming support, and dynamic design rule checking to ensure that equipment and cable connection types are compatible and meet specifications. Users can apply an extensive range of schematic/drawing dress-up, annotations and symbols.

Most shipboard electrical systems are complex, and ELD provides cable routing and system navigation aids throughout the electrical network. An extensive connectivity/continuity analysis tool manages off/on-sheet connectors and retrieves the next schematic needed.

A useful feature is the management of bounded zones and diagrams. For example, in the conceptual design phase, 3D volumes are defined by structure limits. During preliminary steps, the product will provide a schematic representation associated with a bounded zone. It will maintain the link between electrical equipment and bounded zones. Therefore, users are able to associate equipment with a bounded zone. Then, in subsequent preliminary steps, users will complete space reservation and re-use 3D volume representations with the ship's preliminary layout. Users with the ELD and SDI workbenches can directly access the EDSA Micro Systems AC/DC circuit analysis programs. See the Analysis section below for details.

3D Waveguide Design (WAV) and 3D Waveguide Diagrams (WDG)

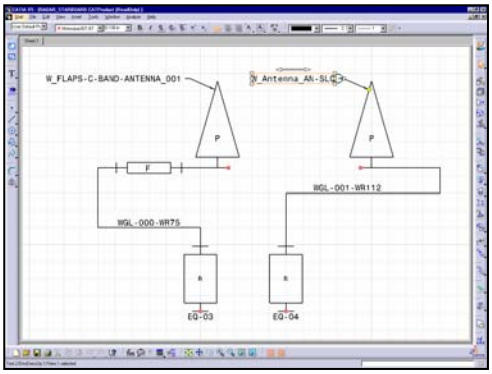


Waveguides are common components in military Command, Control and Communications (C3) systems found aboard ships and aircraft. These antenna systems transmit and receiving high-frequency radio waves. Waveguides are found in telephone, satellite and other high-speed communication systems as well. Design is particularly challenging because these electro-mechanical devices involve precise specifications and exacting dimensional control. CATIA 3D Waveguide Design (WAV) supports the design of the antenna guide itself, its mounts, penetration and support details through bulkheads, decks, fuselages, and wings, plus all cable and connectors feeding the system.

CATIA ***3D Waveguide Diagrams*** (WDG) provide general diagramming tools with industry standard symbols for defining all components, connections and sub-assemblies. Diagramming

functions provide line, equipment and component definition, graphic editing, specification entry, quick copy, and off-page connectors for managing large diagrams. Customization tools adapt *3D Waveguide Diagrams* to comply with company graphic standards and project-naming conventions. The combination of *3D Waveguide Design* and *3D Waveguide Diagrams* allows users to leverage specification data captured in the diagram to automate equipment placement, select 3D components from catalogs, check waveguide schematic lines for completion, query parts and check that all components are functionally and physically correct.

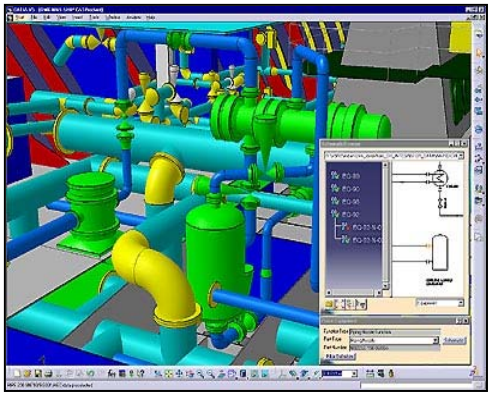
Inheriting specifications from 2D diagrams reduces data entry and eliminates errors. Allowing waveguide schematics to drive design dynamically maintains consistency between the waveguide schematic and the 3D design. The customer's design process benefits from improved design quality, improved productivity and reduced cycle time. *3D Waveguide Diagrams* provides industry standard logic symbols. Special graphics conventions also are available when 3D waveguides are used in 2D drawings.



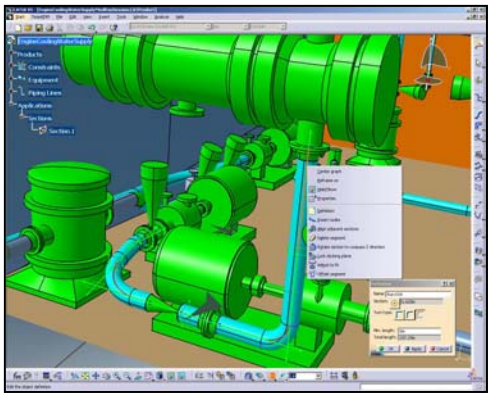
Cross Discipline

Equipment Arrangement (EQT)

CATIA ***Equipment Arrangement*** (EQT) provides tools to build and manage equipment found in ships, offshore platforms and maritime machinery. Examples include boilers, vertical vessels, compressors, pumps, heat exchangers, material handlers, electrical equipment and robots. The tools focus on creating intelligent representations and arrangements of equipment that capture all appropriate information. EQT is fully integrated with piping, tubing HVAC, electrical and waveguide diagrams.

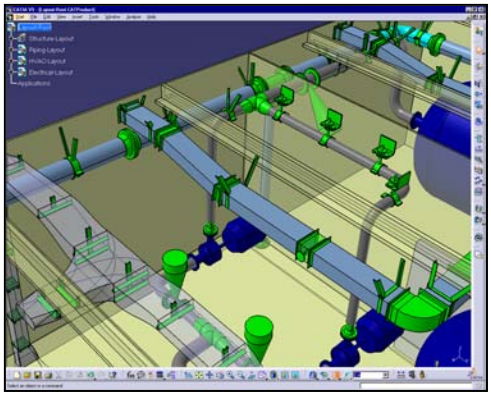


With intelligent equipment arrangement, the user is able to more productively create and validate a design. In addition, captured intelligence can be re-used for downstream design processes, providing additional benefit to the customer's overall design processes. The EQT product gives users the power to manage their systems from initial design to ship outfitting, commissioning and operations.



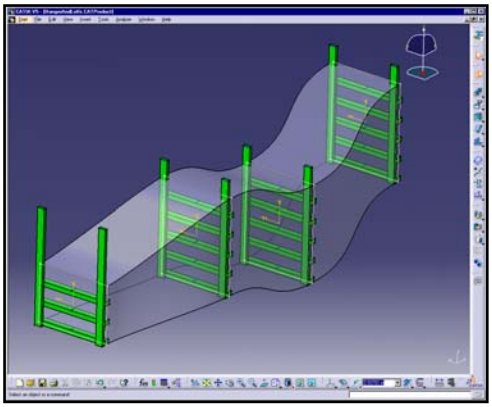
Hanger Design (HGR)

CATIA ***Hanger Design*** (HGR) designs hanger supports for lineal on-board systems like piping, HVAC, electrical and signal cable trays or conduits. Some vessels may have as many as 100,000 hanger supports. Thus, Hanger Design is a welcome productivity addition to the suite of IBM PLM outfitting applications.



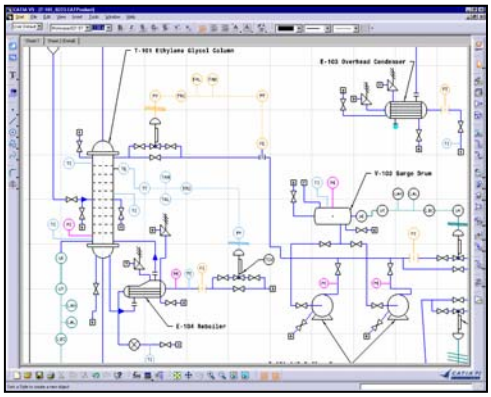
Hanger Design is fully integrated with the 3D systems products, including HVAC, electrical, piping, and waveguides. *Hanger Design* automates space reservations for routing and the placement of individual hanger systems. All hanger parts and catalog hierarchy can be defined by the user.

User tools manage catalogs and specifications. Knowledge Rules automate the proper selection of hangers for different support conditions based on project specifications, safety standards, accessibility, or other design considerations including temperature, radio interference, or hazardous materials conveyance. User productivity is further enhanced with dedicated pathway definition tools that assist with single or multi-



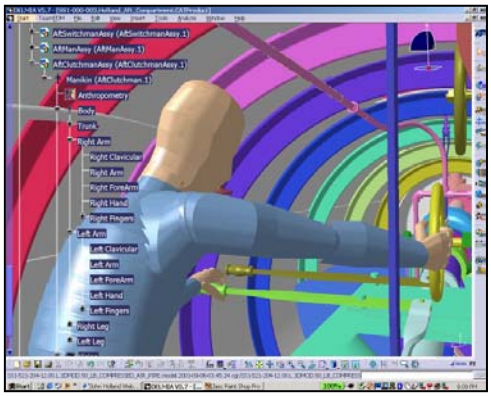
hanger placement, inserting hangers in a loft pathway or connecting hangers at a user-defined attach location.

System Diagrams (SDI)



CATIA ***Systems Diagrams*** (SDI) is a common platform product for all CATIA diagram applications. SDI is used as a foundation product for CATIA *Piping and Instrumentation Diagram* (PID), *Tubing Diagrams* (TUD), *Waveguide Diagrams* (WGD), CATIA *HVAC Diagram (HVD), Electrical Connectivity Diagrams (ELD) and EDSA 3D Electrical application*. It gives users the power to manage their complete diagram design and development. This platform encapsulates diagram functionality that is common to the various diagram applications. This common functionality is based on the concept of an intelligent diagram on which appropriate design information is captured.

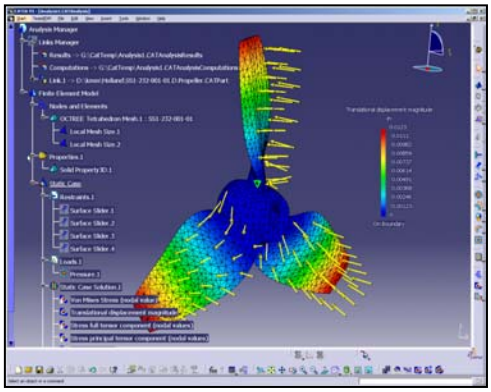
Human Builder (HBR)



Human Builder (HBR) creates and manipulates standard digital humans for early human-product interaction analysis. Human figures help provide insight into crew interactions with systems for understanding ergonomic conditions and limits. In modern ship design, *Human Builder* would be used in conjunction with *Human Measurements Editor* and *Human Posture Analysis* for advanced, detailed digital human creation and analysis to improve human comfort, performance and onboard safety.

Analysis

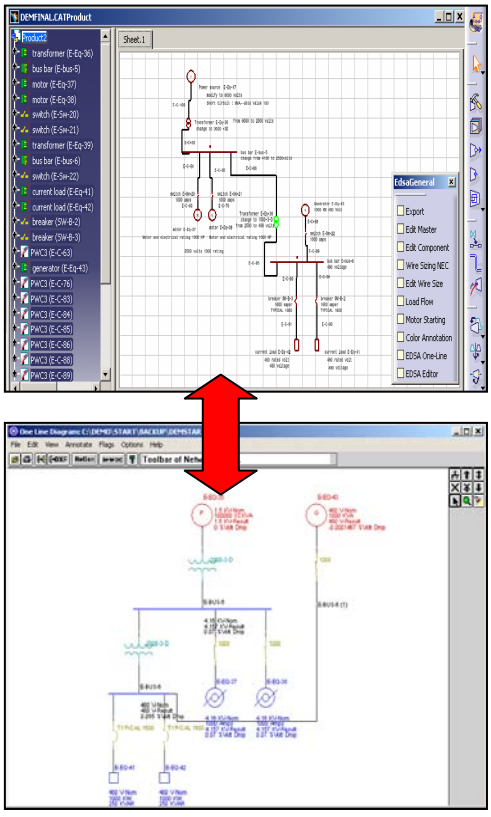
Generative Part & Structural Analysis (GPS)



CATIA ***Generative Part & Structural Analysis*** (GPS) performs part stress and vibration analysis, including contact analysis in part assemblies. It is the basis for all other structural analysis products in CATIA Version 5. It performs structural analysis (building the Finite Element Model (FEM), solving, limited post-processing) of individual parts and can be expanded for advanced surface meshing with CATIA FEM Surface.

CATIA ***Structural Analysis*** performs advanced pre-processing of simulated load conditions, FEM meshing and results calculation. Post-process functions display the results in reports and graphics. Analysis can include deformation studies of individual parts or entire assemblies, VonMises stress diagrams like the one shown here, displacement of parts/assemblies and concentration of principle stresses. Special reports can be produced to document testing conditions and summary results. Structural analysis typically follows a cycle of steps where parts or assemblies are identified for analysis, load conditions are defined, and analysis performed. A review of the results may lead to a part or assembly redesign, a change in shape, a change in connection, or reinforcement of high-stress points. Often, several analysis cycles are performed before an optimal solution is reached.

The fact that the CATIA analysis model is based on the same design model and reuses both the geometry and the assembly constraints is a major benefit. Users can immediately modify their designs and re-analyze them, reducing the number of cycles required before optimal designs are achieved.



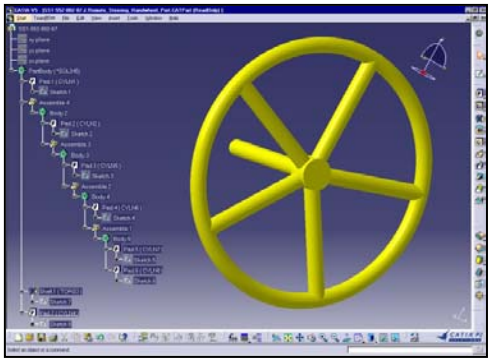
EDSA 3D Electrical

EDSA Micro Corporation of San Diego, California, a CATIA CAA development partner, provides electrical simulation tools that are accessible directly from the CATIA Electrical Connectivity Diagram (ELD) workbench. Within EDSA, the user can perform power analysis and calculations to ensure power quality and reliability of the design system and AC/DC voltage drop calculation (for wire breaker sizing). Simulation solvers and on-the-fly analysis are carried out for systems under design. EDSA offers a comprehensive array of simulation models -- more than 70,000 in all -- each independently verified by world standards bodies including Den Norsk Veritas, ISO 9001 and NFPA.

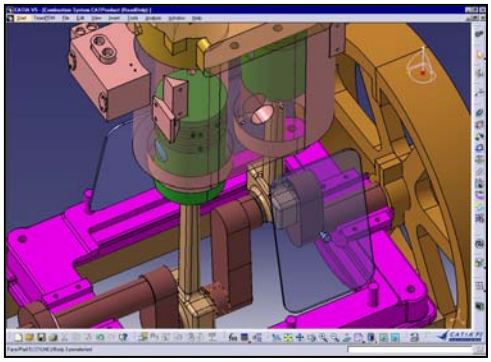
Mechanical CAD

PLM Solutions suite also offers more than 35 individual mechanical CAD products ranging from Wireframe and Surfacing to Sheetmetal. Only a few – those most commonly used in shipbuilding -- are highlighted in this section.

CATIA Part Design (PDG) and Assembly Design (ASD)

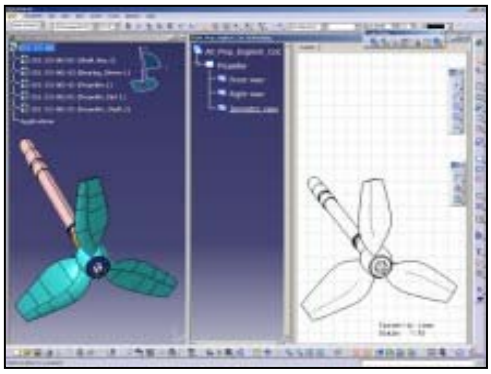


Of the entire CATIA portfolio, these two applications are the most frequently used. CATIA ***Part Design*** (PDG) provides an associative, full-featured 3D geometric modeler with full feature specification (hole definitions, circular pads, cutouts, bevels, etc.). Advanced features include flexible, post-design 3D parameterization and part sketching with 3D designs-in-context.



CATIA ***Assembly Design*** (ASD) manages assemblies of parts and integrates drawing generation. Users build mechanical assemblies by imposing geometric or mathematical constraints between parts such as contact, concentricity, or remain-parallel-with. Assemblies are managed in hierarchical arrangements of parts using a top-down or bottom-up approach. Parts and sub-assemblies are easily reused in the assembly without data duplication. Workbench tools provide exploded parts views as well as collision and clearance checking. Tools also provide automated BOM generation.

Generative Drafting (GDR) and Interactive Drafting (ID1)

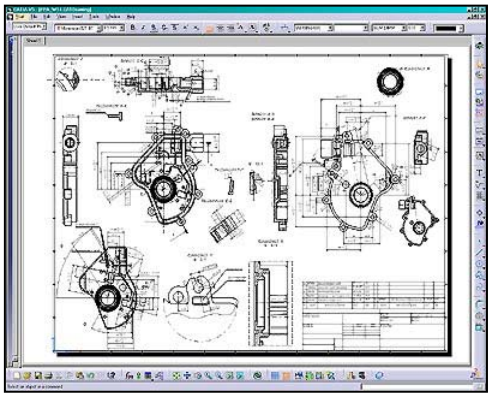


Generative Drafting (GDR) automatically generates 2D drawings from 3D parts or assemblies of parts. Automatic dimensioning, text annotation and bills-of-material can easily be created in CATIA. From the 3D digital mockup, drawings are extracted automatically.

Most modern shipbuilders now try to minimize the number of drawings needed to build a ship. They rely instead on accurate 3D mockups, extracting drawings only if needed.

Generative Drafting automatically generates associative drafting from 3D mechanical designs and assemblies produced with CATIA. Dimensions can be automatically generated with control over their placement. Users are able to add post-generation annotations as dress-up features. Particularly useful in production and manufacturing is the associativity of the drawings to the 3D digital DMUs of shipboard systems. A change in the design and layout models can instantly be

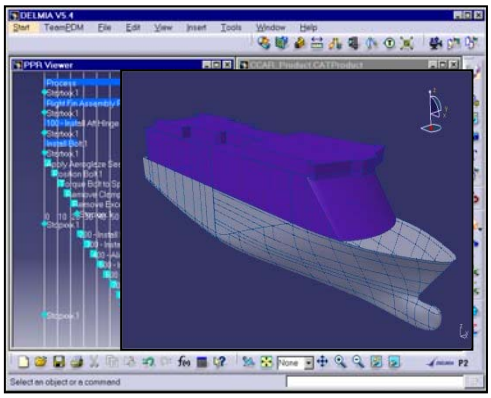
reflected in new, updated master drawings. An additional benefit is that ***Generative Drafting*** can easily export drawings in the DXF file format sometimes used by other drafting programs.



Interactive Drafting (ID1) is often used along with *Generative Drafting* for document dress up (callouts, annotations, approval/revision tables, etc.). It is a full-function drafting application offering highly productive and intuitive drafting. ID1 offers dimensioning of symbolic representations, automatic arrowhead orientation, inter-feature dimensioning (Piping, Tubing, Structure), and the ability to dimension distances/angles between technological features of a same discipline -- structural plates, for example. This functionality relies on the fact that some features ”know” how they should be related to another part dimensionally. Therefore, according to the specific know-how of a discipline, only realistic and customized dimensions will be created. As a result, the end-user will be more efficient in dimensioning distances/angles between such features.

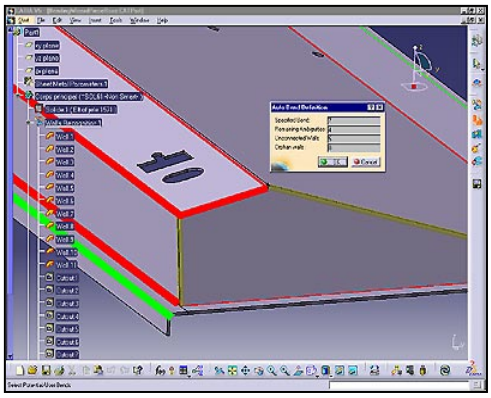
ID1 offers National Language Support for view names. For instance, when the language is changed (English to German for example), view names will change automatically in the product feature tree when the model is opened.

Wireframe and Surfacing (WS1)



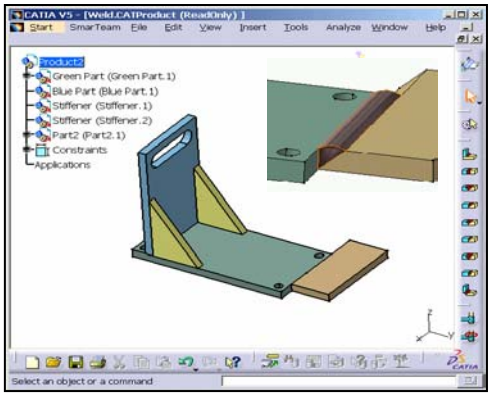
CATIA ***Wireframe and Surfacing*** (WS1) workbench provides a comprehensive set of tools for defining the generating reference lines for surfaces to follow. A variety of surfacing methods and treatments for edges and corners is possible. The product structure maintains a full history of surfaces developed. Therefore, it is easy to change features or modify contours.

Sheetmetal Design (SD2)



CATIA ***Sheetmetal Design*** (SD2) is a workbench for developing and testing parts and assemblies made from sheetmetal and for generating related production drawings. SD2 respects material behavior (thickness, spring back and minimum bending radius). Knowledge rules can check for the impact of cutouts and perforations for fasteners or access to interior areas. Workbench functions can test folding/unfolding sequences. Extensive visualization support can show how mounted systems within relate to openings and if proper tolerances and clearances are maintained.

Weld Design (WD1)

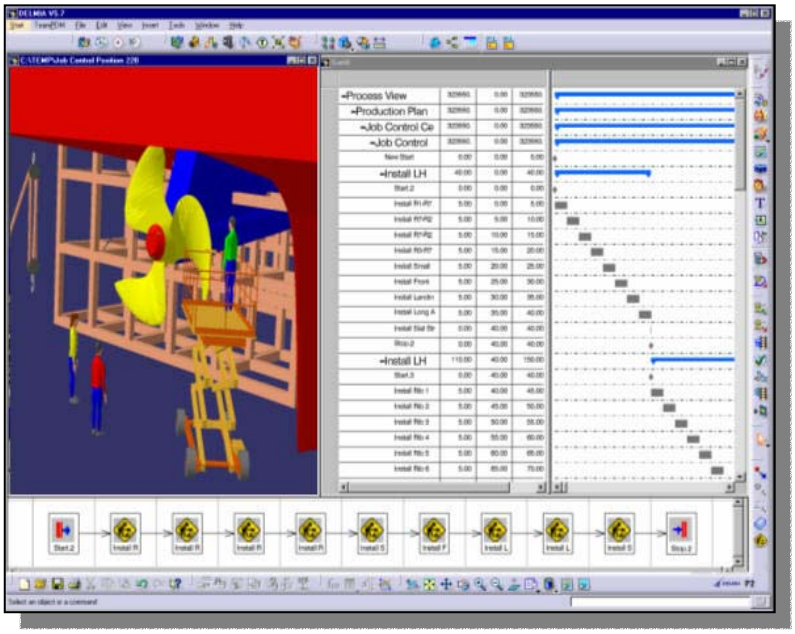


CATIA ***Weld Design*** (WD1) is a dedicated workbench for creating welding operations. Parts are automatically prepared for welding, with associative assembly features added to the welded physical part(s). Multiple parts can be welded on the same edge or, optionally, on the contact zone on the welded part instead of the entire edge. Associative 3D geometry and 2D annotations maintain design intent.

Weld designs are fully integrated within ***Drafting***. Thus, welds are automatically generated in orthographic views, sections and section cuts and impacted by the hidden-line-removal visualization mode of the assembly. 2D weld annotations are also created automatically. Within the 3D design, the mass and inertia of the weld ribbons are added to the mass and the inertia of the whole assembly so users who specify the weld material can perform relevant calculations.

Welds can also be integrated in the clash collision analysis of the assembly. The weld attributes can be taken into account in Knowledgeware products as geometric parameters (length, width…) or technological parameters (quality…).

Manufacturing Authoring Tools



Digital Manufacturing and Simulation

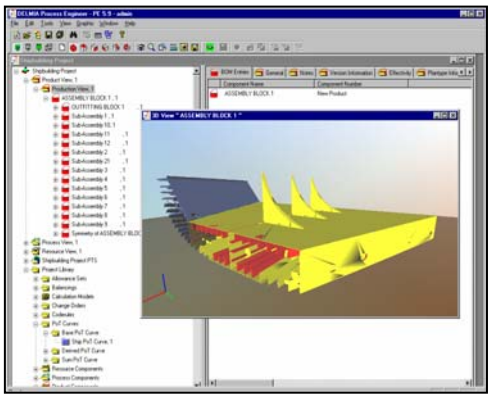
DELMIA solutions focus on the processes and resources needed for manufacturing and integrating shipboard systems and structural blocks. Typically these products and assemblies are defined in CATIA by one or more of the solutions described elsewhere.

DELMIA solutions provide digital manufacturing and simulation support from concept design through manufacturing execution. They support production planning, facility layout, process verification, time and cost estimating, human factors and process flow analysis. The key benefits of using DELMIA for Digital Manufacturing are:

- A centralized, organized manufacturing information repository called the Manufacturing Hub, which can be shared by planners, estimators, manufacturing engineers, industrial engineers, lofters and health and safety engineers.
- Elimination of unbuildable situations and the resultant engineering change orders and first-time quality problems.
- Increased productivity from using the same 3D model-based environment (CATIA solutions) for Design-for-Manufacturing and Design-for-Assembly activities.
- Minimization of efforts to accommodate unplanned events by leveraging the easy-to-use, high-level, model-based process planning of DELMIA with linkages to current design engineering data.
- Ability to do “what-if?” scenarios and understand dynamic relationships between design, layout and production systems behavior.

Process Engineer

DELMIA ***Process Engineer*** enables the user to define, develop and analyze alternative approaches to the manufacturing process. It provides the user with the ability to easily organize and visualize relevant planning data.



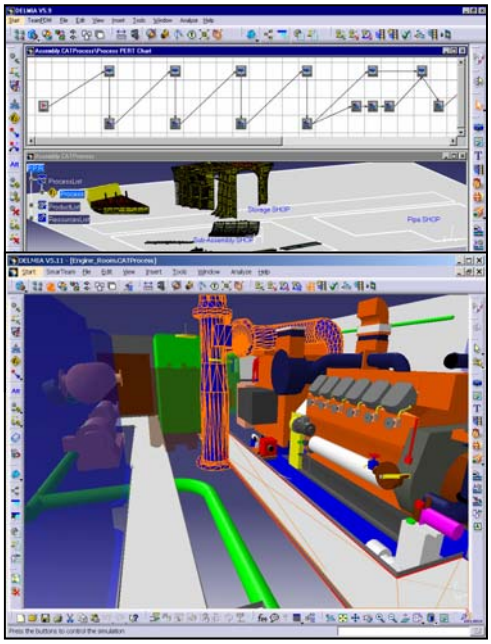
The ***Process and Resource Planning*** module is used to generate a process graph of the sequence of operations and then to automatically generate a manufacturing concept.

Based on internationally established methods for time measurement, the ***Standard Time Measurement*** module delivers a detailed process description for both manual and semi-automated manufacturing processes. It determines the required standard times and thoroughly documents them. The ***Product Evaluation*** module enables the user to filter specific product configurations and evaluate the cost of the proposed production plan versus the cost targets.

For the communication and sharing of information across the enterprise, DELMIA offers the ***PPR Navigator for Manufacturing*** module for accessing all manufacturing data. All ***Process Design and Analysis*** modules are based on one Product, Process and Resource (PPR) data model. This allows users to share the same data among different locations, departments and disciplines throughout the enterprise and across the supply chain.

DPM Assembly

DELMIA ***DPM Assembly*** is used to develop more detailed process plans based on the geometry created in CATIA and other CAD systems. Product, Process and Resource information is directly retrievable from the *Manufacturing Hub* database. *DPM Assembly* is used to determine the correct assembly process for the products and provides the user with the ability to evaluate alternative jig and fixturing approaches for the assembly sequence.

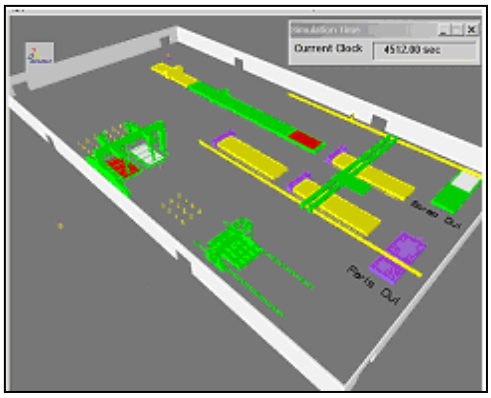


The collision detection capability of *DPM Assembly*, and its ability to manipulate individual parts and subassemblies along their assembly paths, gives the user the ability to quickly conceptualize and verify alternative assembly sequences. The in-process states of the components are automatically generated for each process step and can be used to support Electronic Work Instructions (EWI).

DPM Assembly provides a Gantt- and Pert-charting interface, giving the user an easy-to-use method of developing the sequence of operations, timing and dependencies. *DPM Assembly* also is particularly useful in validating production and maintenance scenarios.

Collision detection and kinematic capabilities verify that sequences are possible and within limits of tooling or transports like cranes, hoists or positioning fixtures. Electronic work instructions (EWIs) for shop personnel and maintenance crews can be automatically generated with a single mouse click, executing a customizable Visual Basic script. These EWIs can be created in html or xml formats with embedded hyper-links, providing the user with easy navigation of the required process steps and support information.

Process Engineer and *DPM Assembly* generate the process and resource information in the *Manufacturing Hub*, which makes it possible to then generate a discrete event factory model of the process flow with the ***Quest*** product described below.

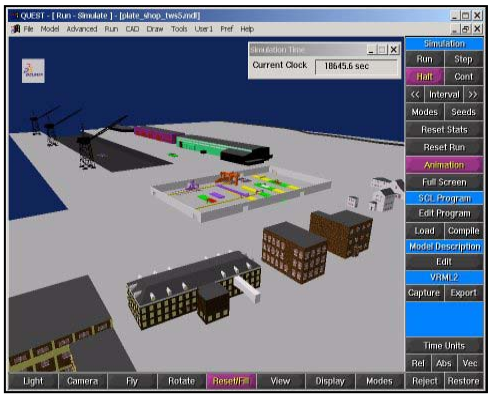


QUEST – Discrete Event Simulation

DELMIA ***QUEST*** supports discrete event simulation and is a combined analysis and visualization workbench providing stochastic analysis of the combined probabilities of all events in the process flow. This provides a realistic prediction of the throughput of the shops and flow time through the shops while identifying bottlenecks and reports on asset utilization. Through a

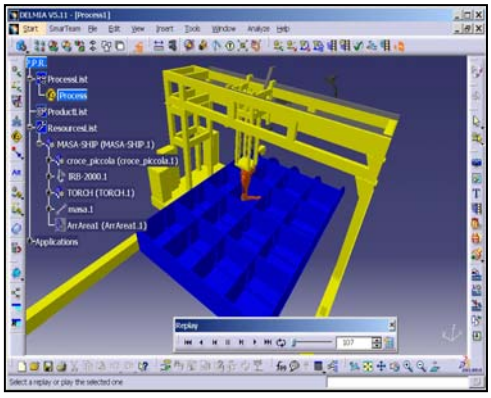
high-level simulation language, users define custom behaviors for the movement of process machines, humans and materials. Sequences between dependent steps of manufacturing can be linked together to validate and visualize the impact of process flow decisions or the startup of a process.

QUEST provides tools for simulation programming, process flow analysis, statistics capture and reporting, and visualizations. *QUEST* allows models to be transferred from the 2D world into the 3D world. In this way, the model can start off at a simple conceptual level of detail and then evolve as the design process progresses. This approach eliminates the need to create two different models on different software. *QUEST* also provides complete CAD capability to create and modify geometries or to import geometries from a wide range of CAD packages.

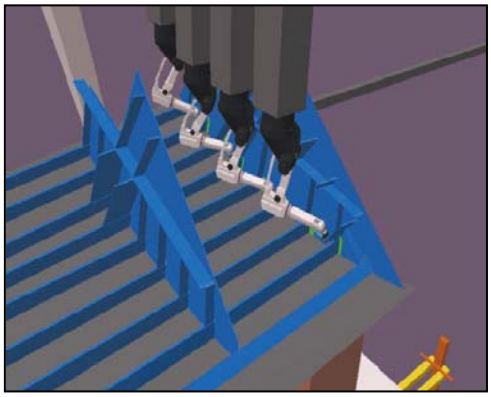


2D and 3D geometries can be saved and used in different models. Performance statistics can be displayed or sent to a file for use by other software packages. A wide range of standard reports is available and customized reports can be easily created.

Workcell Layout & Simulation



DELMIA ***Workcell Layout & Simulation*** products are kinematic simulation tools for design and evaluation of automated equipment and off-line programming of robotic workcells. Incorporating real-world robotic and peripheral equipment, motion attributes, kinematics, and I/O logic, *Workcell Layout & Simulation* products generate extremely accurate simulations and provide the ability to optimize robot locations, motions and cycle times. This helps users to eliminate costly collisions between robots, parts, tools, fixtures and surroundings. Kinematic devices defined in the *DMU Kinematics* module (available in both CATIA and ENOVIA) are directly importable into *Workcell Layout & Simulation.* This application includes Gantt- and Pert-charting capabilities, which provide the user with an easy method for generating the interactive functionality of workcell devices when developing scenarios to simulate a manufacturing process scenario.



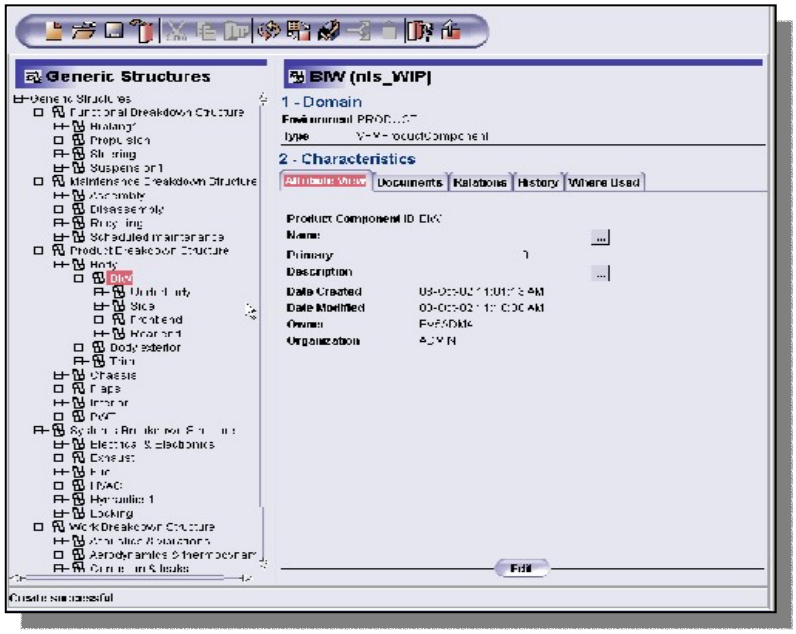
UltraArc

DELMIA ***UltraArc*** is a simulation tool for designing, optimizing and off-line programming of robotic and arc welding workcells. UltraArc allows the user to create complex paths on intricate weld seams using macros that help ensure conformance to weld procedure specifications (WPS). Path modification tools control

changes in robot operation to maintain WPS conformity, as well as pre-defined robot controller sensor procedures. UltraArc's capabilities include automatically generation and download of robot motion and process programs using built-in libraries of robots, positioner tables, gantries, weld guns, and related equipment. Automatic external axes computation is available. Other workcell components can be created in the integral CAD package or imported from other CAD packages via IGES, DXF, and optional direct translators. A built-in surface modeling package provides easy modification and optimization of imported surface data. Robot weld process parameters also are supported. Physically based modeling and minimum energy relation techniques are used to simulate cables influenced by gravity loads, stiffness effects, accelerations due to robot motions, and contact forces.

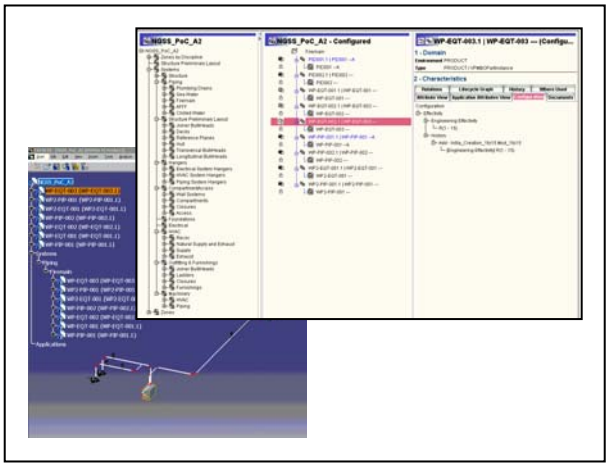
UltraArc optimizes critical factors such as position, speed, acceleration, cycle time, collision detection, and multiple I/O communication. Built-in functions simplify assignment of kinematic motion attributes to the fixture. An interactive Gantt-style pop-up chart is utilized to define the sequence of operation. Users are able to perform "what-if?" analysis by testing different fixture combinations and to verify robot/torch interaction with tooling. Calibration functions utilize the robot as the calibration tool, eliminating the need for expensive measurement equipment. The precise position of components, tool point offsets, and robot signature assure off-line program accuracy when downloaded into the robot.

Lifecycle Management Solutions



Product Data Modeling

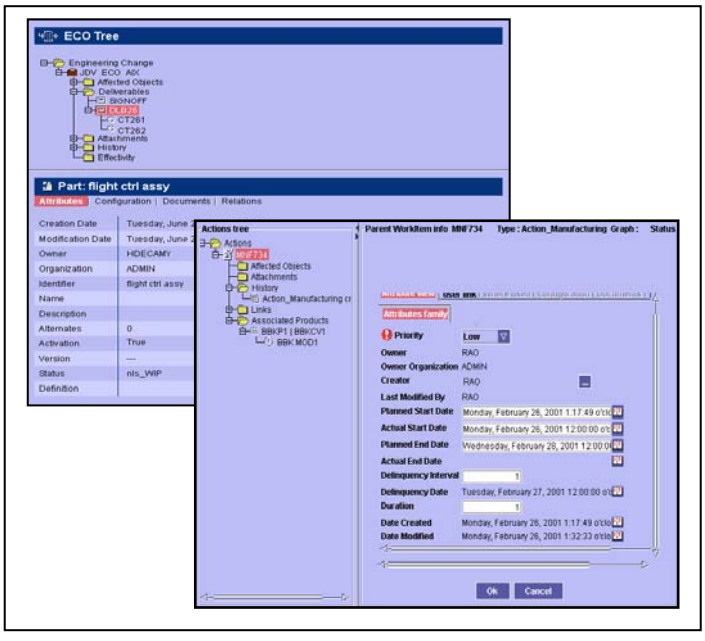
EBOM Product Definition (PDC)



ENOVIA ***EBOM Product Definition*** (PDC) provides functions for both managers and technical users. Product planners may take advantage of the *product class editor* to define product family hierarchy. Technically oriented design managers may utilize the *component editor* and *zone editor* to define a product "work organization" based on components (engine, body, electrical, etc.) or zones (geometrical areas in a digital mock-up), a practice common in many manufacturing industries.

EBOM Product Definition allows for the definition of conditions under which an object should be included or excluded from a configuration. In its basic form, product definition consists of an effectivity expression indicating that the object is valid for a particular product, such as a hull number.

Engineering Change Management (ECM)

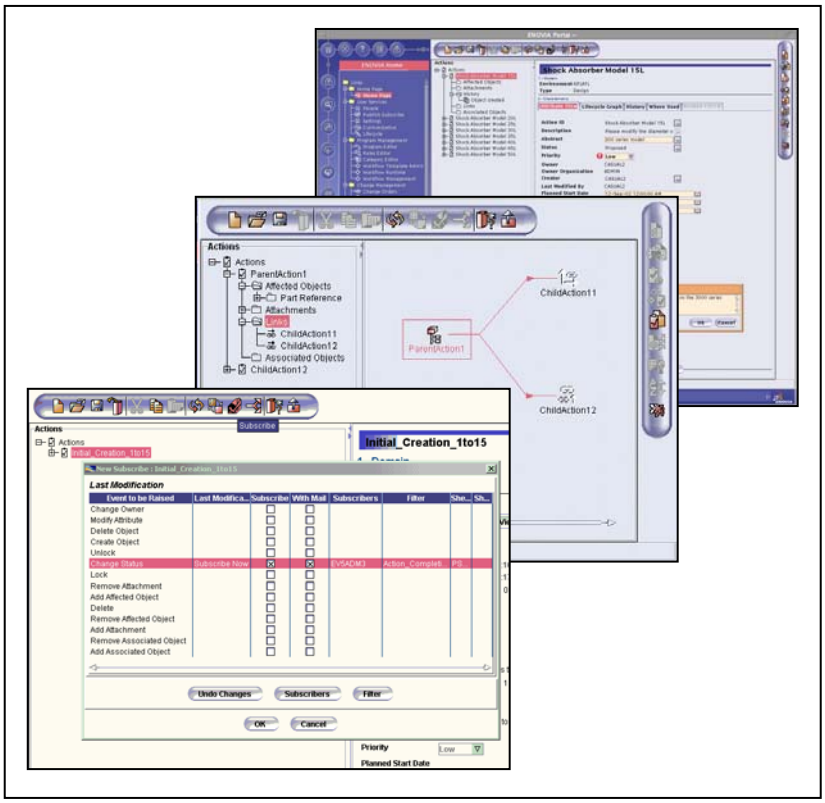


An ECR process captures a request for change and routes it to various related departments for validation and impact/cost analysis. An ECO process captures a full definition of work required to perform a change, which may be planned as a series of linked work packages that are systematically distributed to all affected organizations.

ENOVIA engineering change processes are unique because these processes internally employ Actions as task components. This provides a degree of ad-hoc capability to the formal change processes due

to the dynamic nature of the Action, which can be broken into smaller, assignable subordinate Actions, or sub-tasks. Sub-tasks, in turn, may be transferred to other people or organizations.

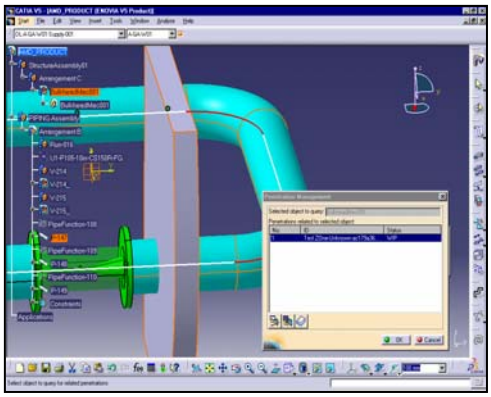
Action Management (AED)



ENOVIA ***Action Management*** (AED) is used to informally track changes to part references and product structures. An Action may be defined by a supervisor and assigned to a designer who will perform the change. For added flexibility, changes may automatically be recorded as they are made or assigned to the Actions after the changes have been completed. This is especially helpful in early design stages where many modifications to a product structure must be performed rapidly. An Action may easily be broken into smaller, assignable subordinate Actions or sub-tasks for transfer to other people or organizations. An Action also may be linked with other Actions to form a workflow-like task sequence. Supervisors may take advantage of the auto-capture feature for automatic tracking of new part version creation or make use of the delinquency monitoring feature for minimizing late work deliveries. Actions also are used as granular task components of engineering change and workflow processes, which are used in more mature phases of the product development cycle. Furthermore, "Publish" and "Subscribe" capabilities are integrated with Actions. Users may subscribe themselves to an Action and receive notification when its status changes.

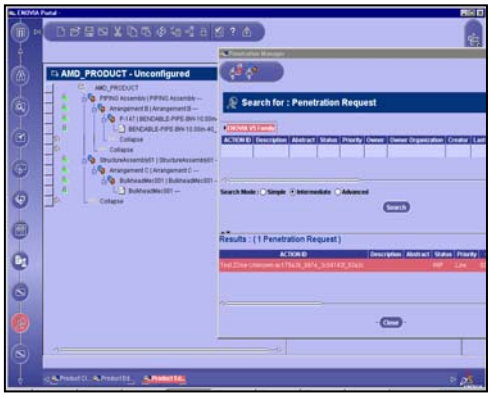
Structure Penetration Management (SPT)

Functional layouts and 3D routing for piping, tubing, HVAC and electrical systems often necessitate penetrations and openings in decks and bulkheads. Penetration requests may require structural analysis and clash detection before an opening can be approved. ENOVIA ***Structure Penetration Management*** (SPT) addresses this requirement.



Owner/operators, yards and suppliers are quickly moving to real-time electronic working environments. To be effective, collaboration requires new tools to manage interdisciplinary work and provide project management control to minimize the negative impacts of one team's work on another. Nowhere is this more evident than in penetration management.

SPT development processes are used when system elements (such as piping or electrical harnesses) must be routed through a solid structure. These processes allow users to identify a real or potential interference using a "penetration request." The request can carry the clash or components involved in the penetration. Administration messaging functions assign the penetration request to a user as a "work-to-do" item to validate, fix or check. *Structure Penetration Management* provides the workflow and interdisciplinary coordination required for penetration requests and interference management and the messaging necessary to reach problem resolution.



Workflow and Standards

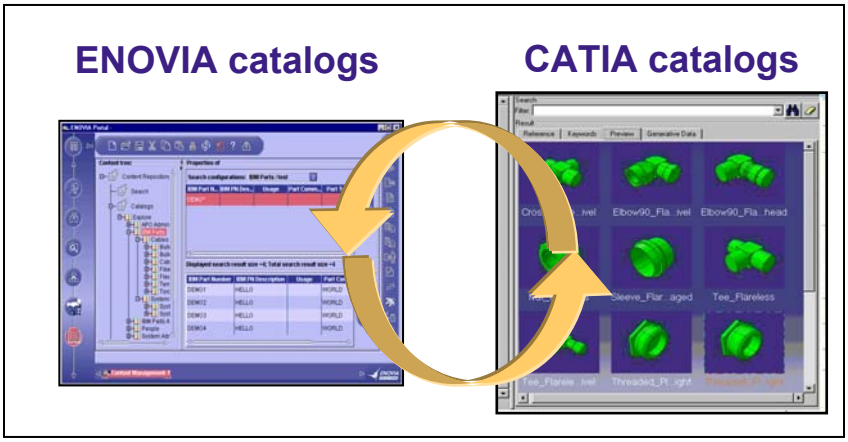
Workflow Management (WFM)

ENOVIA ***Workflow Management*** (WFM) enables business process automation, which contributes to enhanced process performance. Managers in charge of business processes such as engineering changes will appreciate the time saved in activating a process due to the available workflow template (generated by ENOVIA *Workflow Designer*).

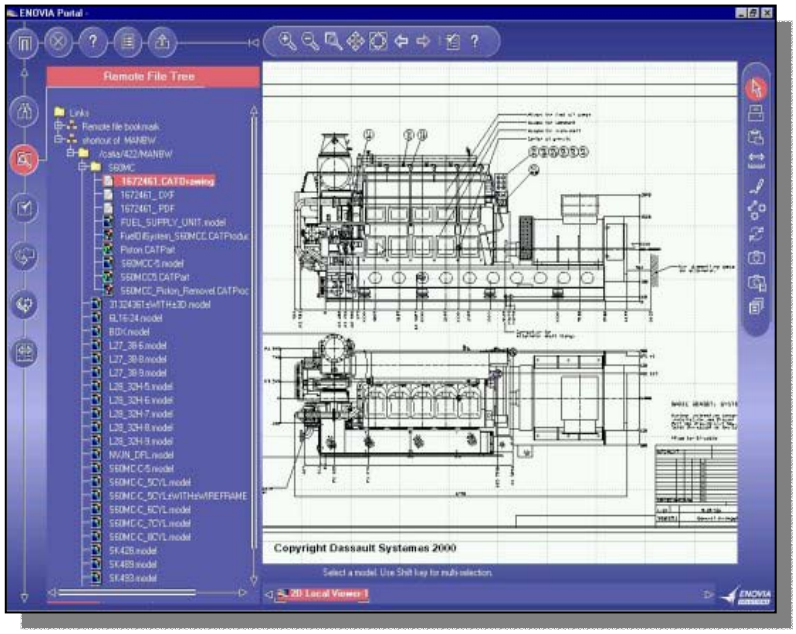
Resource assignment generally is done at the start of the workflow, but it can be adjusted to fall anywhere along the process if an activity is blocked due to resource unavailability. Shipyard staff can access their work-to-do list through a native ENOVIA LCA client or through standard web browsers. This allows external entities (suppliers and partners) to be easily included in a workflow process. A graphical workflow viewer is provided for process owners to monitor process status and progression.

Catalog Management (CTM)

ENOVIA ***Catalog Management*** (CTM) provides an organizational tool for storing parts and documents in catalogs. This enhances data retrieval and re-use across various organizations in an enterprise. It also maximizes the use of standard or manufactured parts in product design, which in turn lowers production costs. Part catalogs in ENOVIA may be designed as multi-level structures based on any desired classification category (mechanical, electrical, hazardous materials, etc.). Keywords or classification parameters are defined for each category for object identification during a catalog search. For instance, the "part" category may contain information on vendor, material, price, code, etc. ENOVIA part catalogs are interoperable with CATIA V5 part catalogs, allowing CATIA users to store CATIA part catalogs in the ENOVIA LCA database directly from the CATIA interface.

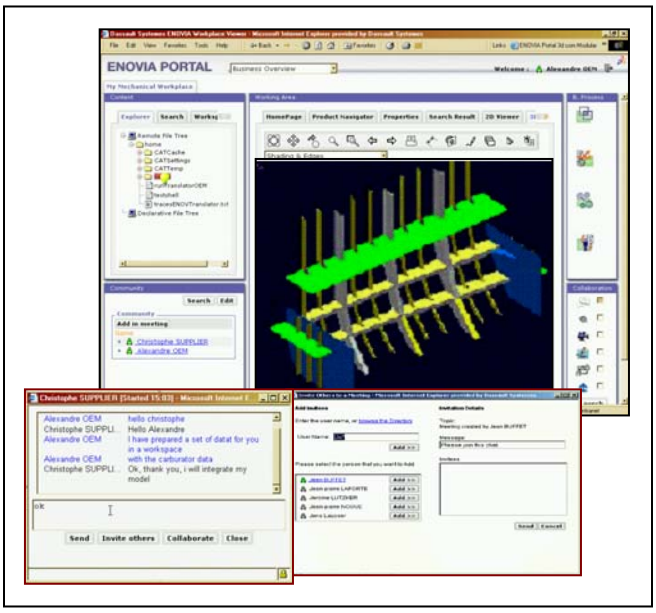


Decision Support



Collaboration and Program Management

3d com Instant Collaboration (I3C)

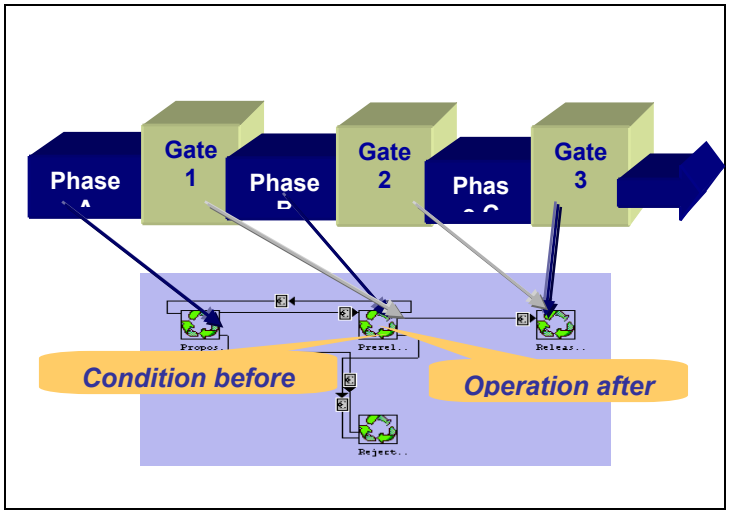


ENOVIA ***3d com Instant Collaboration*** (I3C) enables real-time collaboration between all participants across the extended enterprise. This promotes the sharing of data and ideas that can result in faster time to market and increases in overall product innovation. I3C provides instant collaboration from within DS products; collaboration between communities; a secure collaborative environment; and tracking and storage of information created during meetings. *SameTime* collaboration capabilities are fully integrated in the ENOVIA Portal 3d com solution, providing users with a consistent user interface and behavior.

ENOVIA Portal is a comprehensive set of scalable, open collaborative Web- and Windows-based solutions for the digital enterprise. ENOVIA Portal solutions provide access to and visualization of data stored in multiple underlying systems, including legacy, files, CAx, Web and other data across the extended enterprise. This makes information available to all participants for enhanced decision support and collaboration. It generalizes the use, manipulation and analysis of graphical data for enterprise decision support. Support for multi-source engineering design, manufacturing and service data promotes multi-functional support and product/process optimization.

Visualization, analysis and simulation tools are available that address the requirements of all users, from beginners (intuitive visualization and navigation through a 3D product) to the most experienced (full immersive analysis and simulation). ENOVIA Portal includes a web access component. Value-added solutions on top of the base comprise a set of 3D web visualization and data management solutions, plus an advanced, Windows-compatible component for 2D and 3D DMU manipulation.

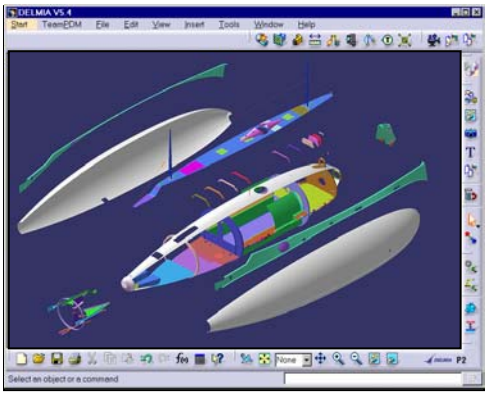
Program Management (PGT)



ENOVIA ***Program Management*** (PGT) is designed for managers and administrators responsible for overseeing several programs simultaneously when all are under development within a single organization. The program editor application is provided for defining programs and the milestones within each program. Program milestones, usually associated with specific dates

or product unit numbers, can be used to configure a product. This practice minimizes the impact of program shifts on the product development process. Another application, the *Lifecycle Editor*, is provided for defining an object's lifecycle. A lifecycle specifies what needs to be done to successfully mature the object to its desired final state. As the object matures, the gates between the lifecycle phases may be used to initiate an approval process or data integration process.

DMU Fitting Simulator (FIT)

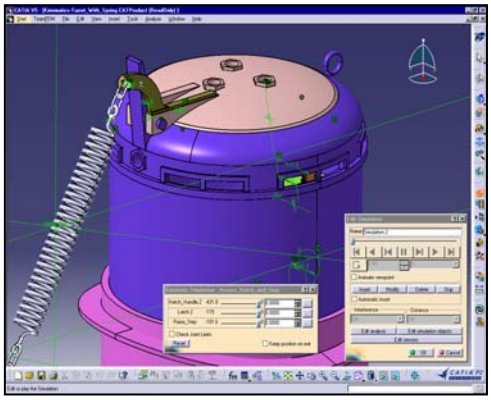


DMU Fitting Simulator (FIT) validates a product design for feasibility of maintenance operations (assembly/disassembly). FIT generates useful information on space reservations for dismantling operations, which must be taken into account in future design modifications. The product also helps to identify the dismantling trajectory of an assembly.

The simulation and analysis tools in FIT address the needs of ship design, construction sequence, machinery outfitting, shipboard maintenance and operations, serviceability and maintainability. Moreover, its animation and video-creation capabilities are useful for sales, marketing and training applications. FIT can handle large and complex assemblies, making it particularly useful in dense shipboard machinery areas.

Fitting Simulator is particularly useful for checking complex part assemblies for correct sequencing and constraints. For example, large equipment and machinery may be digitally "pulled apart," just as one would take it apart manually. The benefit is a more in-depth understanding of how systems work and the limits on their operation. Another benefit is the ability to generate "exploded" parts views of machinery and weapons systems, showing the order in which parts must be assembled to make larger assemblies or finished components. It is an excellent systems documentation tool and can automatically re-create the "exploded parts" views typically found in parts catalogs today.

DMU Kinematics Simulator (KIN)

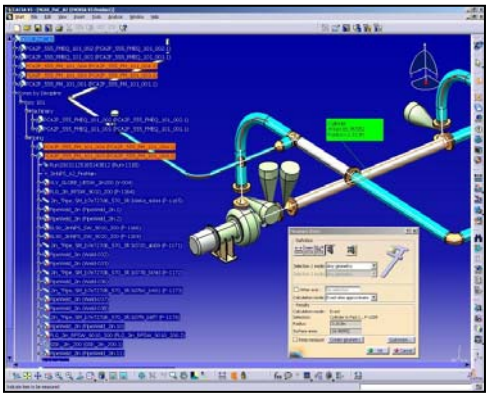


DMU Kinematics Simulator (KIN) defines digital mock-up mechanisms of all sizes by using a wide variety of existing joint types or by generating them automatically from mechanical assembly constraints. KIN simulates mechanical motions through mouse-based manipulation to validate mechanisms and analyzes mechanism motions by checking interferences and computing minimal distances. KIN generates the trace of the swept volume of a moving part to drive further design. It also allows combined simulations through integration with other DMU products. KIN addresses the needs of designers and analysts involved in activities ranging from mechanism design to the functional verification of mechanisms and mechanical systems.

KIN is particularly useful in the simulation of shipboard operations and machinery maintenance. It can be used to validate designs such as lifeboat and davit operations, conveyors and machinery removal and replacement, and weapons systems preparation and use.

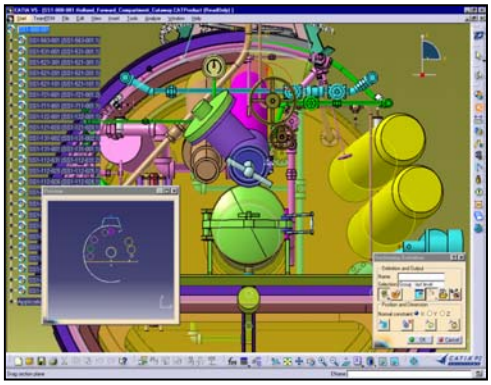
DMU Navigator (DMN)

DMU Navigator (DMN) performs advanced collaborative review of the 3D Digital Mockup (DMU). *DMU Navigator* is a simple-to-use application that enables dynamic tours and navigations through models. A major benefit is the ability to annotate and hyper-link multi-media documents to models. This is very useful in a collaborative project where teams are working in several areas of the ship and need to communicate and track comments as the project develops.



DMU Space Analysis (SPA)

DMU Space Analysis (SPA) performs digital mockup verifications using interference detection, section analysis, measurement and 3D geometry comparison tools. *Space Analysis* is particularly useful in verifying equipment installations and piping arrangements. Clearances and maneuvering room can be important considerations in pre-assembly as well as in operations/maintenance planning.



Rendering

Photo Studio (PHS) and Real Time Rendering (RTR)

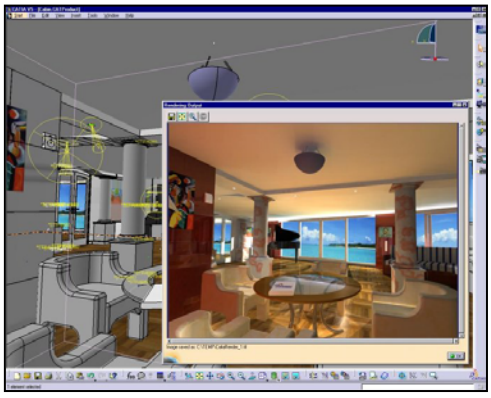
Photo Studio (PHS) generates high-quality photo-realistic images of ships, interiors, equipment and machinery arrangements and spatial layouts. PHS enables designers to define re-usable scene settings and provides instant graphical feedback on any setting modification.

PHS delivers simple and powerful animation capabilities and enables surface verification. This is particularly useful in the layout of critical areas such as navigation stations, where visibility and control access is important. Shipboard areas such as cruise liner theaters, restaurants, entertainment facilities, lounges, atriums and cabins benefit from realistic renderings for decisions about lighting, color and texture. PHS gives a realistic simulation of a design's appearance, complete with textures, lighting characteristics and resulting shades and shadows.

Real Time Rendering (RTR), similar to PHS, is a less compute-intensive solution capable of delivering realistic images with multiple light sources and applied textures. As such, it can be implemented on small workstations and used in rapid prototyping, virtual reality presentations or animations.

Photo Studio Optimizer (PSO)

Photo Studio Optimizer is an essential complement to *Photo Studio* for users who want to create images and movies that match reality. PSO extends the rendering capabilities of PHS with advanced technologies such as global illumination and caustics. The product's 3D texture mapping capabilities allow the user to see, early in the design cycle, what the ship will look like.



Advanced material definitions match reality. PSO offers powerful tools to improve the sensation of looking at a real object. 3D texturing defines a color for each point in 3D space. Spaces and parts look as if they have been carved from a single block of material. Bump mapping introduces apparent surface deviations from the original shape, giving the illusion that the geometry is deformed. Examples are pleated leather, rough metal and waves on the sea.

The rendering quality of PSO goes far beyond graphic card capabilities. Global illumination produces more realistic rendering by taking into account all forms of light: direct, diffuse, glossy, and specular. All parts of the digital mock-up are included in the illumination of the scene. Caustics -- light that hits a reflective or refractive surface -- is reflected or transmitted and forms light patterns on other objects. PSO can accurately render them.

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